REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

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1. REPORT DATE *(DD-MM-YYYY)*	**2. REPORT TYPE**	**3. DATES COVERED** *(From - To)*
13-03-2012	Briefing Charts	

4. TITLE AND SUBTITLE

Detectability of Delaminations in Solid Rocket Motors with Embedded Stress Sensors
(Briefing Charts)

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
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5d. PROJECT NUMBER

5f. WORK UNIT NUMBER
Q09Y

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

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9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

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10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S NUMBER(S)
AFRL-RZ-ED-VG-2012-076

12. DISTRIBUTION / AVAILABILITY STATEMENT

Distribution A: Approved for public release; distribution unlimited. PA# 12225

13. SUPPLEMENTARY NOTES
For presentation at the JANNAF Joint Propulsion Meeting in San Antonio, TX, 30 Apr – 4 May 2012.

14. ABSTRACT

Briefing Charts. A finite-element-based numerical model is employed to investigate the effect of propellant-insulation delaminations on the radial stress distribution at the bondline during the cooling of a solid rocket motor consisting of propellant, insulation, and casing. With the assumption of stress sensors evenly distributed along the propellant-insulation interface, the way that the debond angles, number of sensors, and sensor accuracy are related is established. Two approaches are proposed to evaluate the detectability of debonds based on the sensor readings. Furthermore, a quantitative mapping obtained between the debond angle and the sensor data is used to inversely estimate the delamination damage. It is demonstrated that the proposed methods can be used to detect delaminations in solid rocket motors.

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON**
					Dr. Timothy C. Miller
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**			**19b. TELEPHONE NUMBER** *(include area code)*
Unclassified	**Unclassified**	**Unclassified**	SAR	16	N/A

DETECTABILITY OF DELAMINATIONS IN ROCKET MOTORS WITH EMBEDDED STRESS SENSORS

JANNAF S&MBS Meeting
30 April – 4 May 2012

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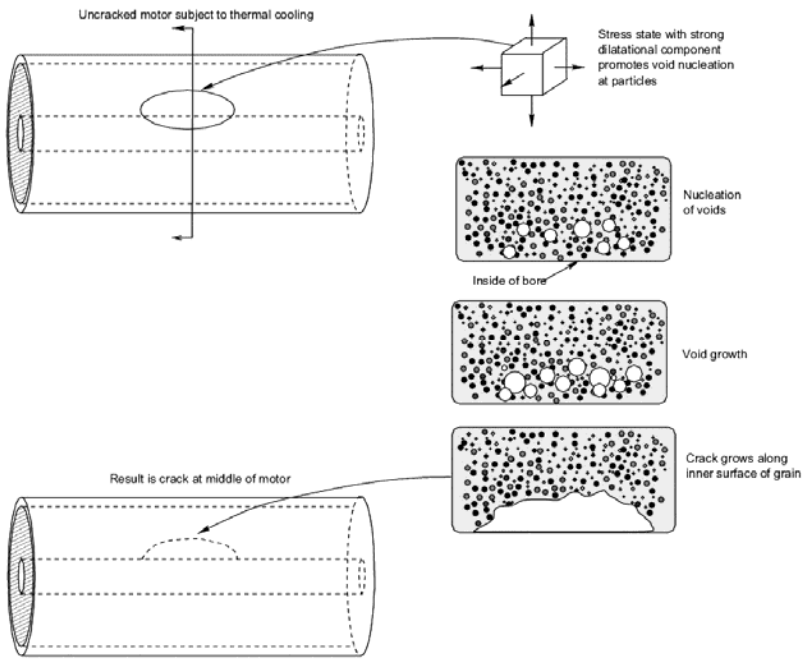
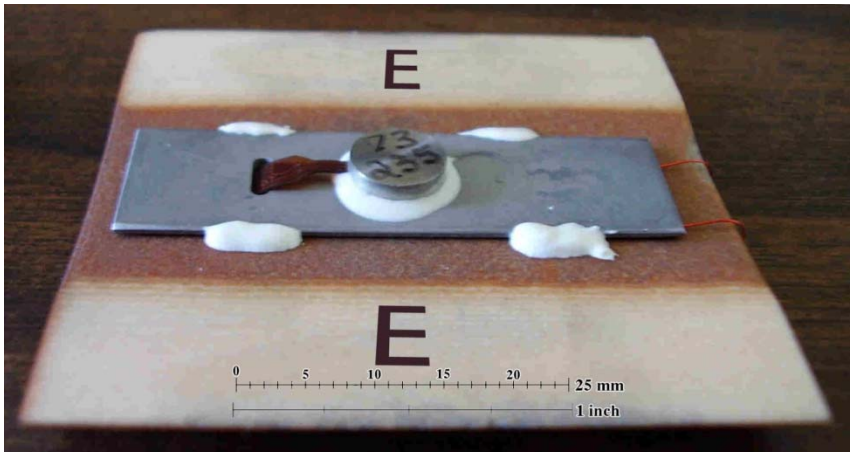
Introduction





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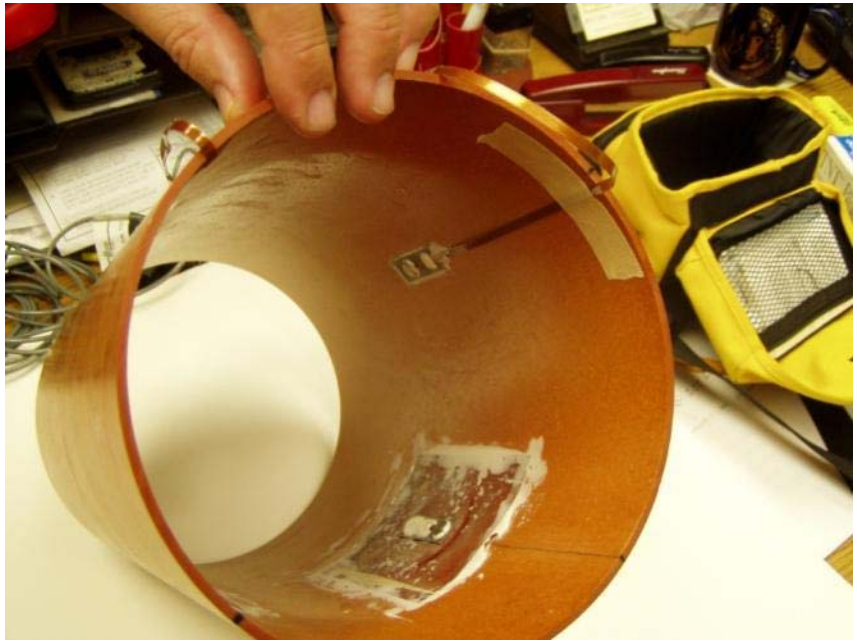
Introduction (Continued)



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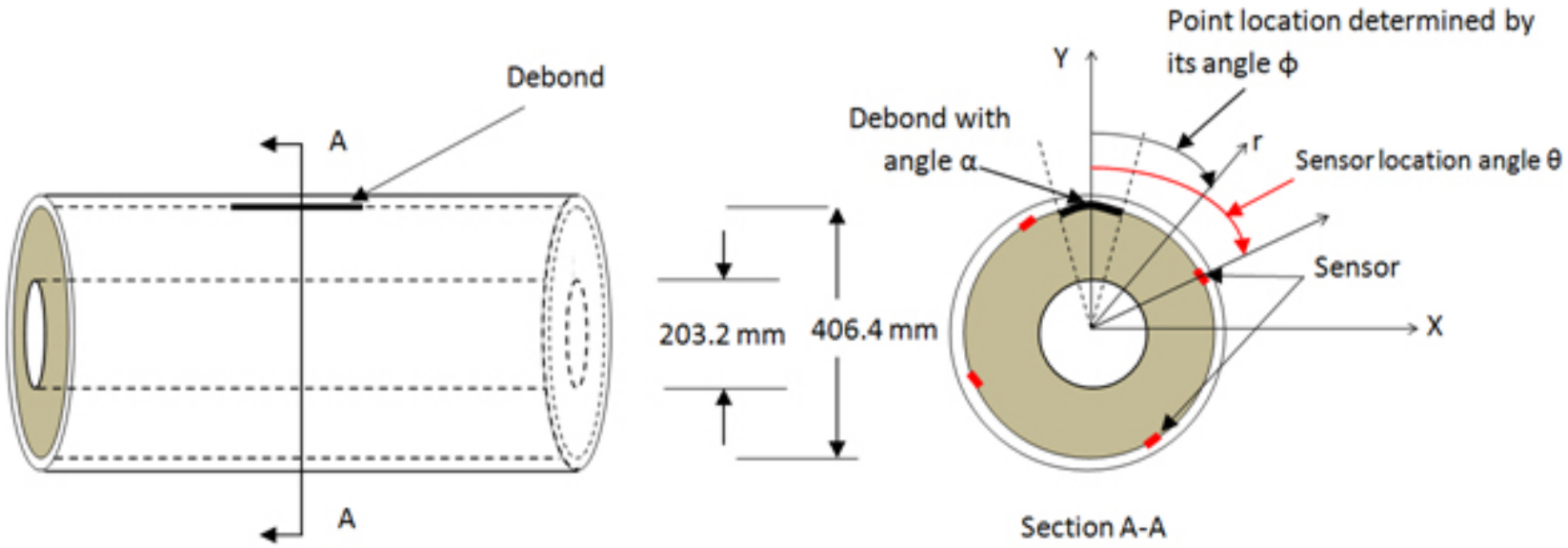
Finite Element Model Details



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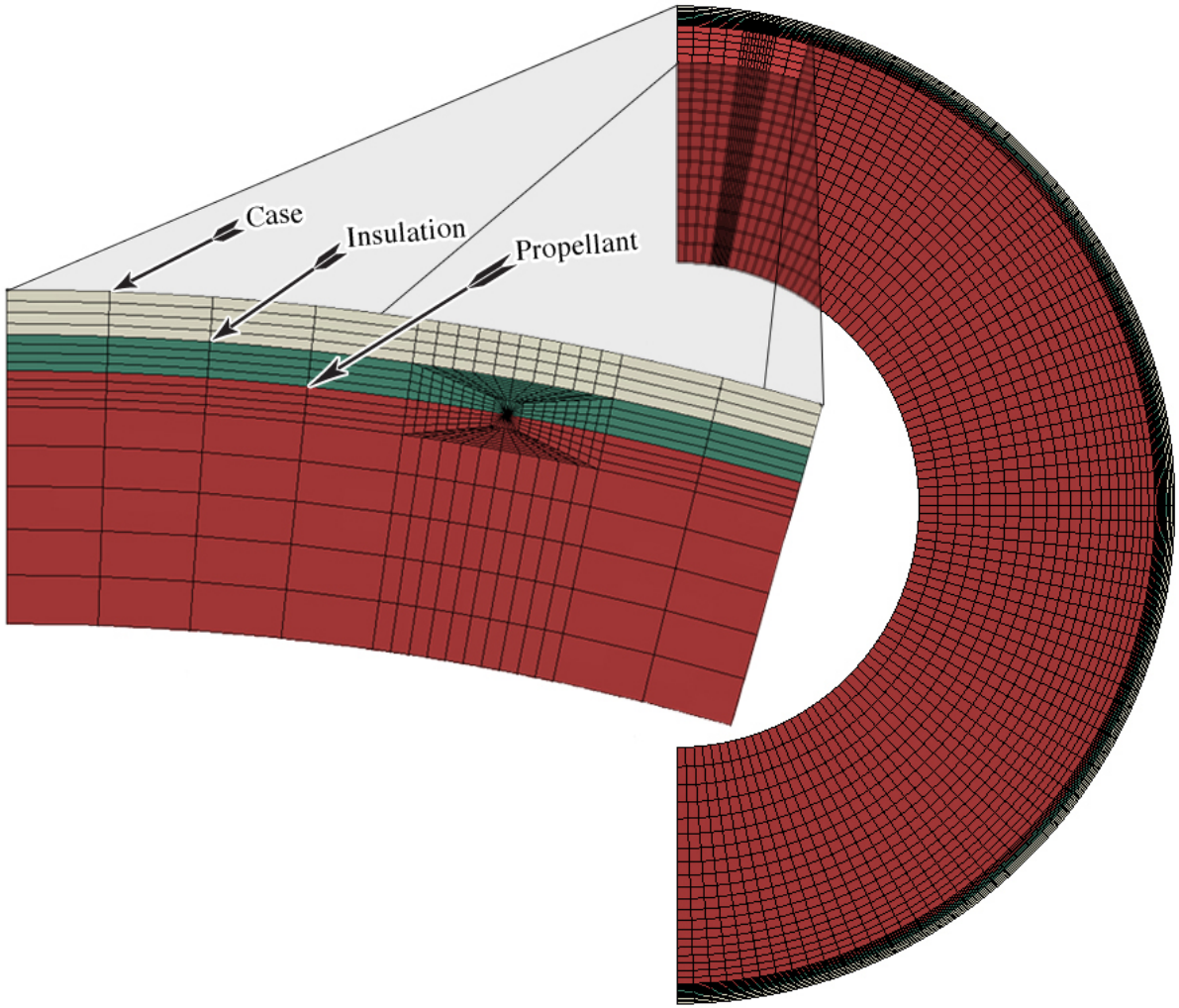
Finite Element Model Details (Continued)



Case: Graphite-epoxy motor case, quasi-isotropic, linear elastic

Insulation: EPDM, temperature-dependent linear elastic

Grain: HTPB, temperature-dependent linear elastic

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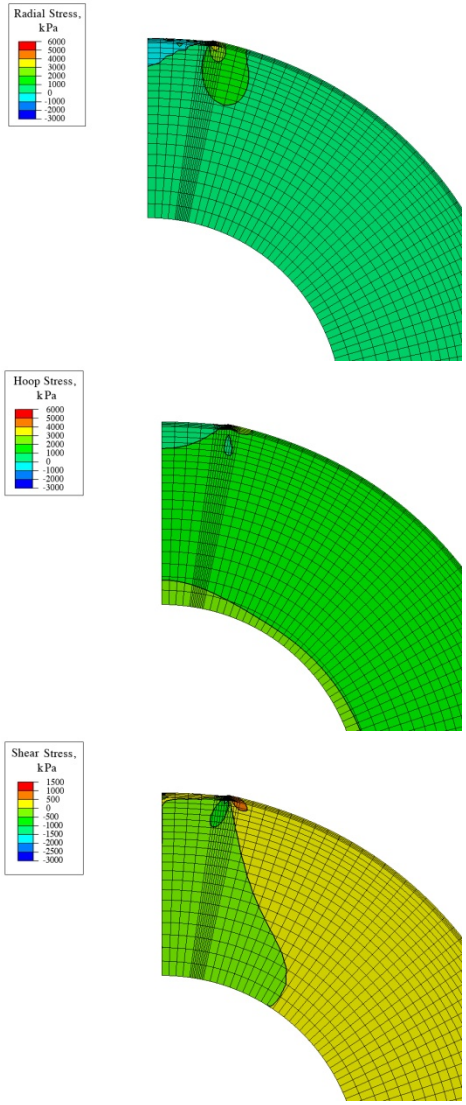
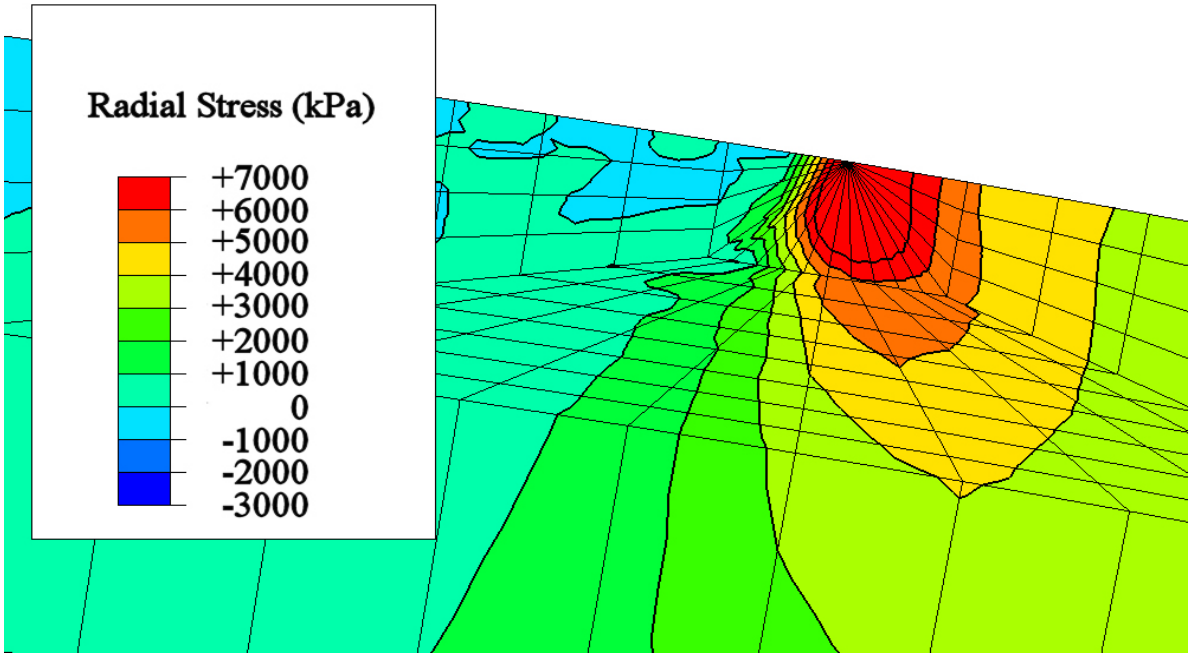
Results and Discussion
Contour Plots





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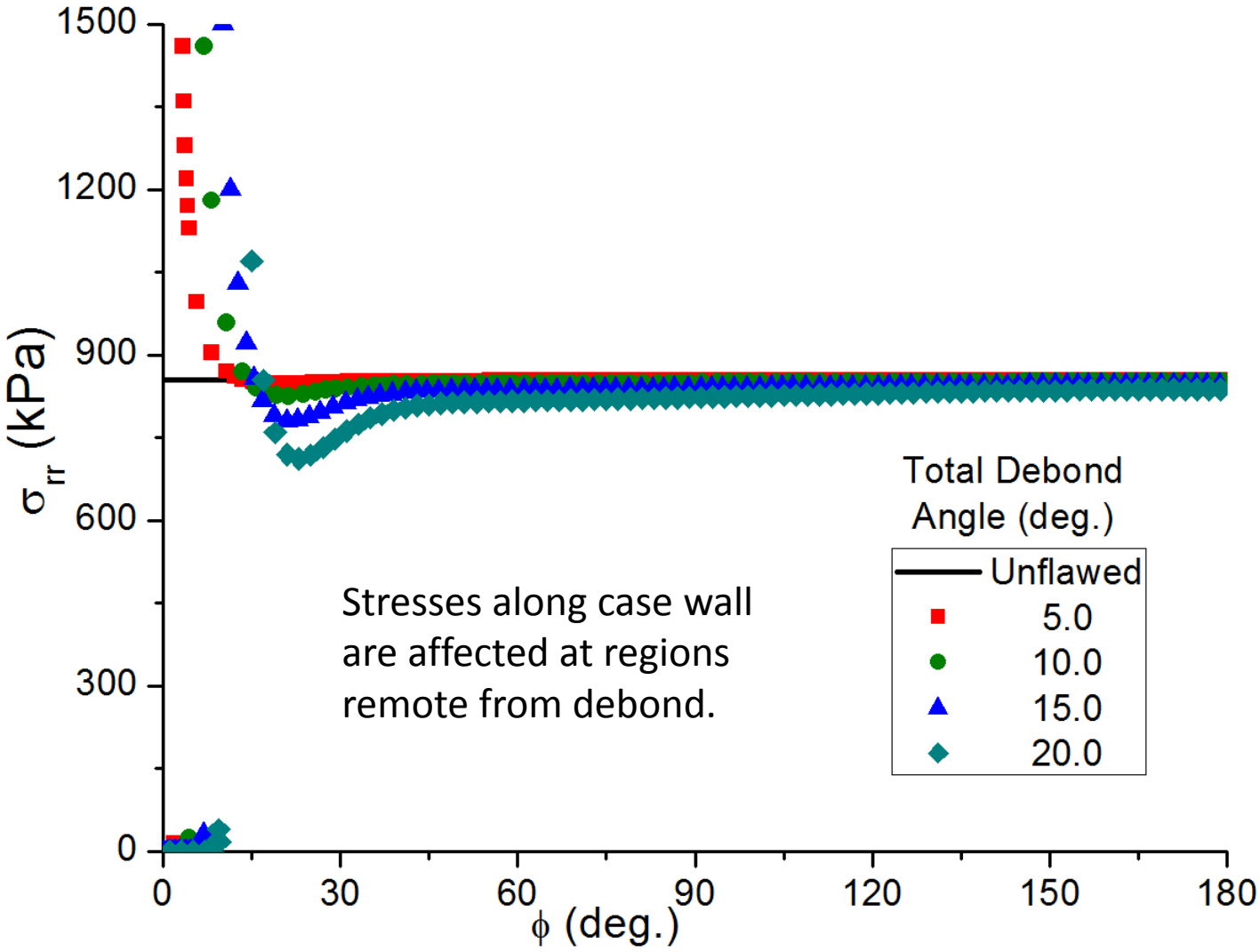
Results and Discussion
Case-Wall Radial Stresses



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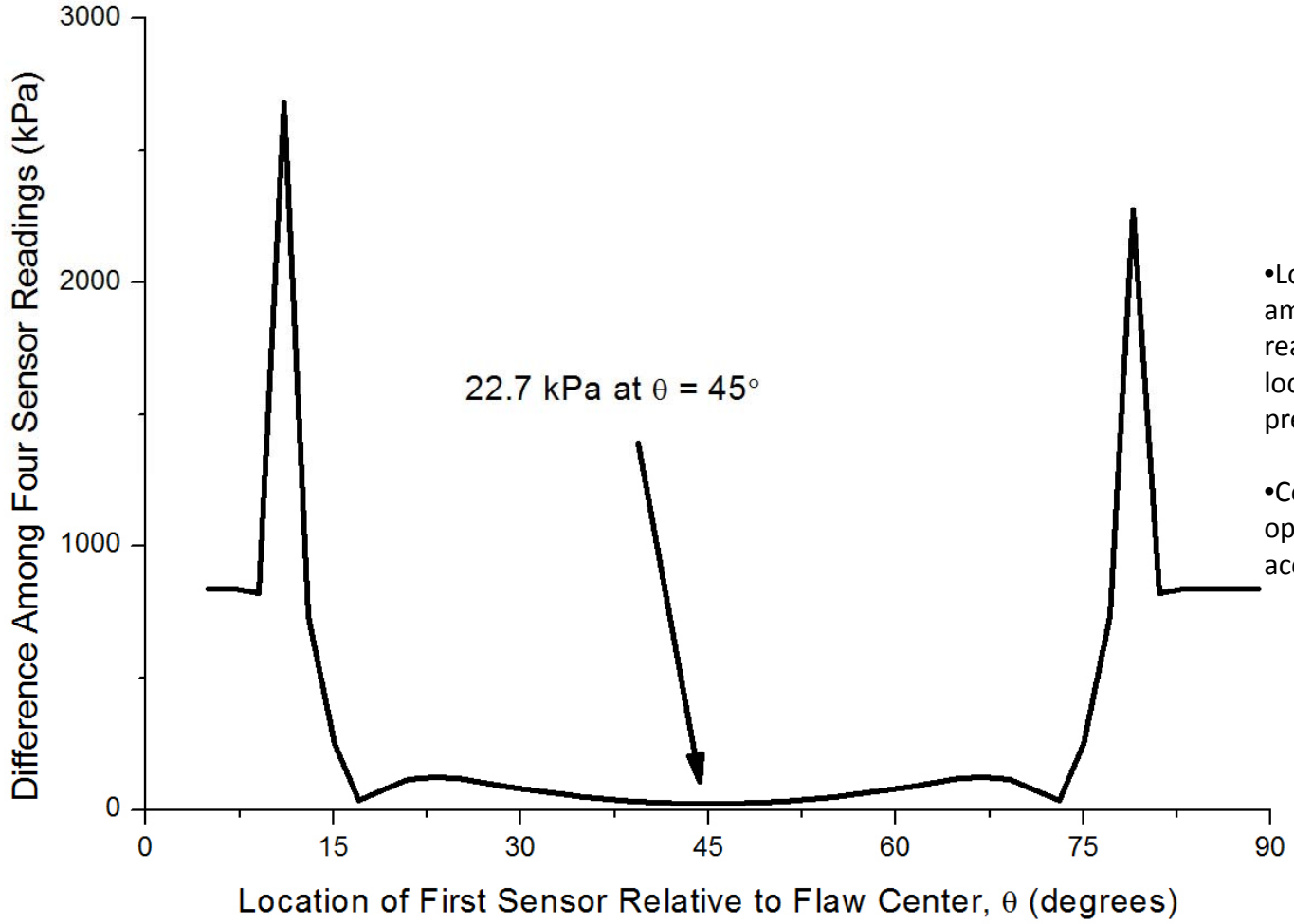
Results and Discussion
Differential Method



- Looking at the difference among the (four) sensor readings at "least-optimal" location gives conservative prediction of detectability.
- Compare reading at "least-optimal" location with sensor accuracy (10 kPa or less)

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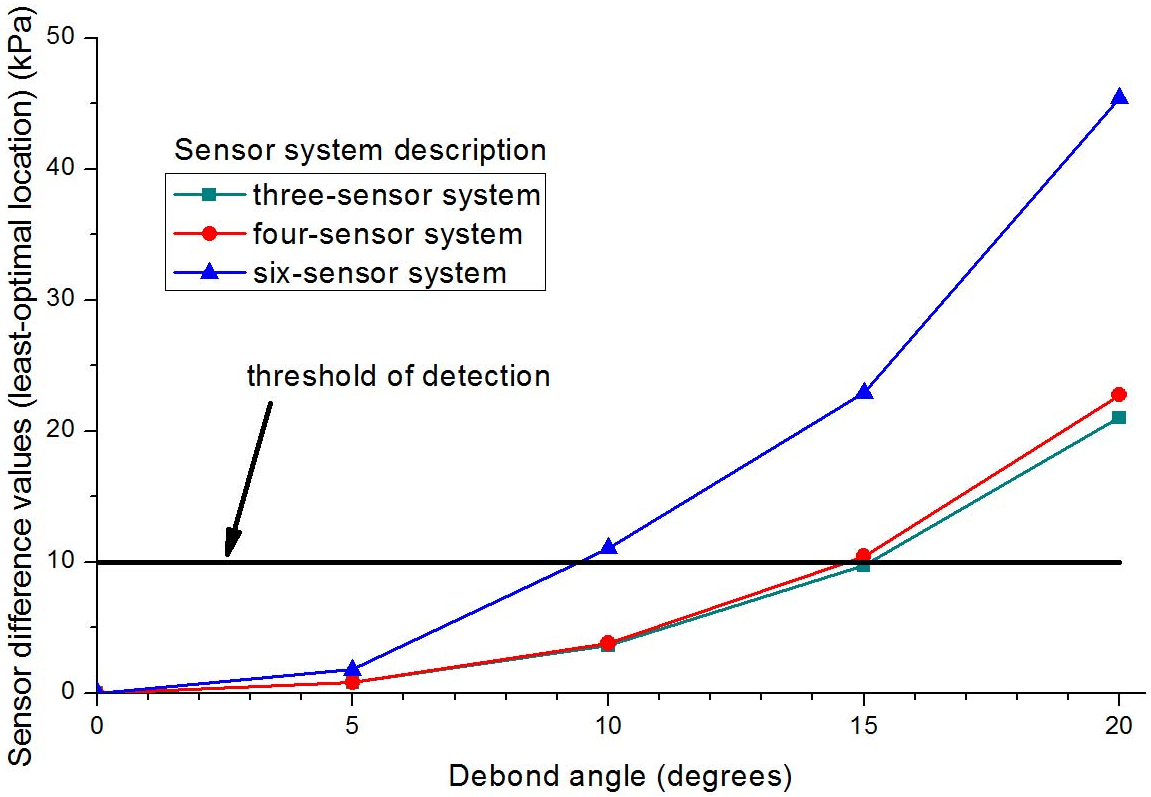
Results and Discussion
Differential Method



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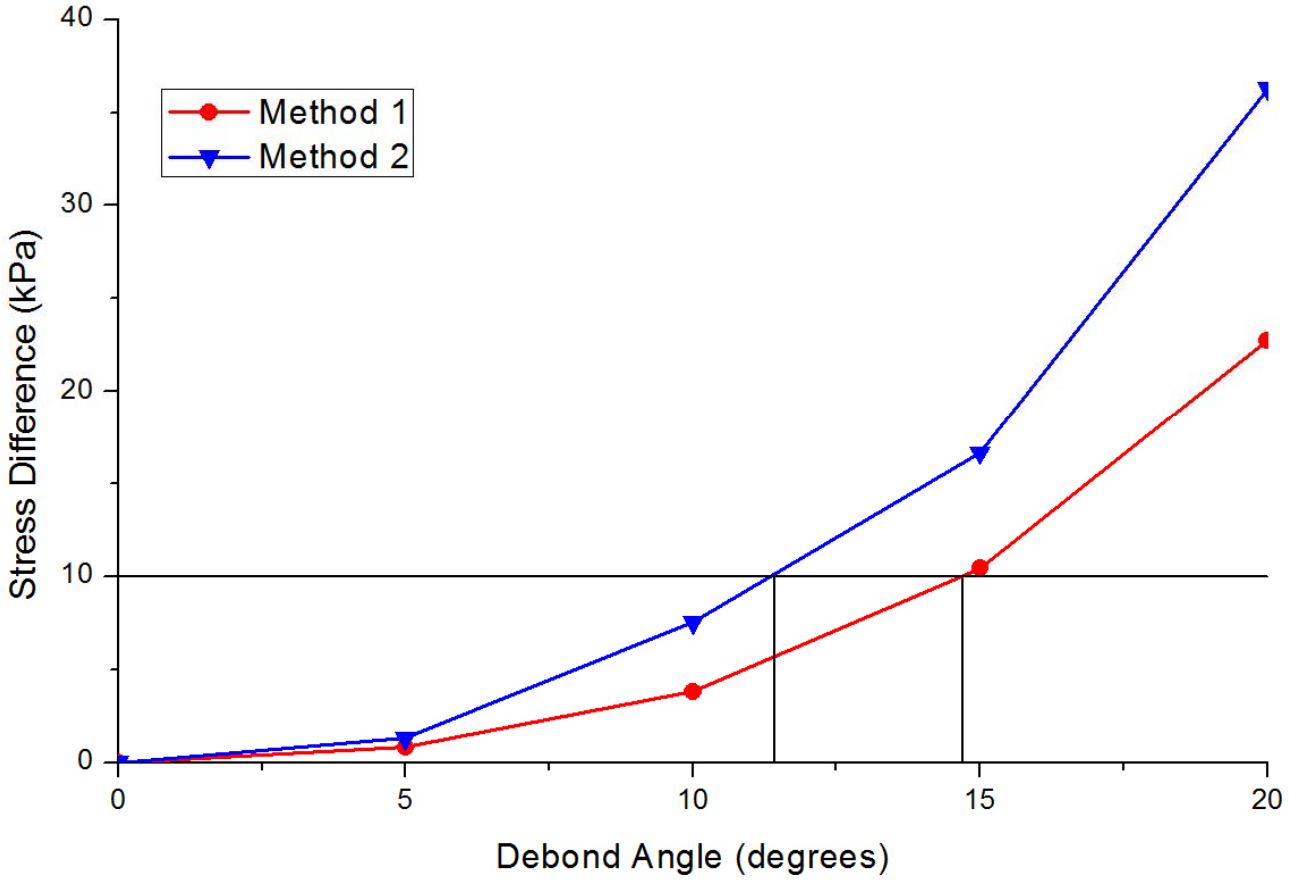
Results and Discussion
Baseline Method



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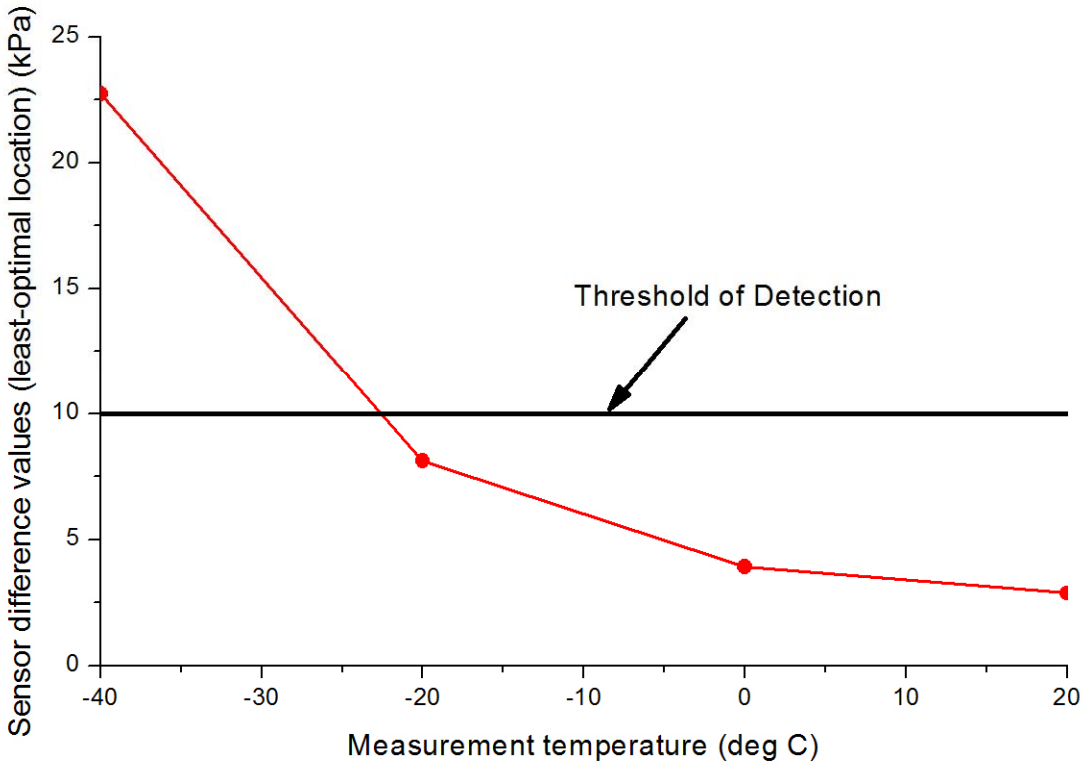
Results and Discussion
Effect of Test Temperature



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Results and Discussion
Effects of Sensor Failure

Four-sensor system with one failure:
Stress difference at “least-optimal” location = 14.4 kPa

Three-sensor system with one failure:
Stress difference at “least-optimal” location = 0.2 kPa

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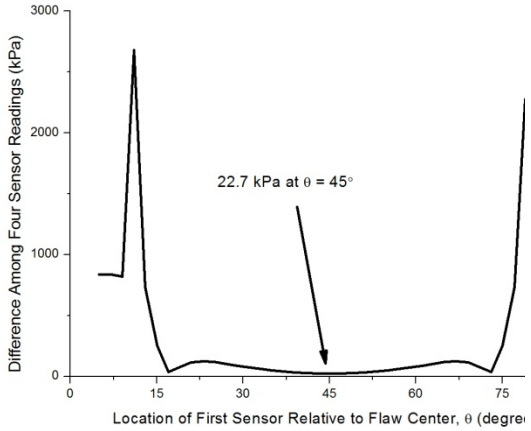
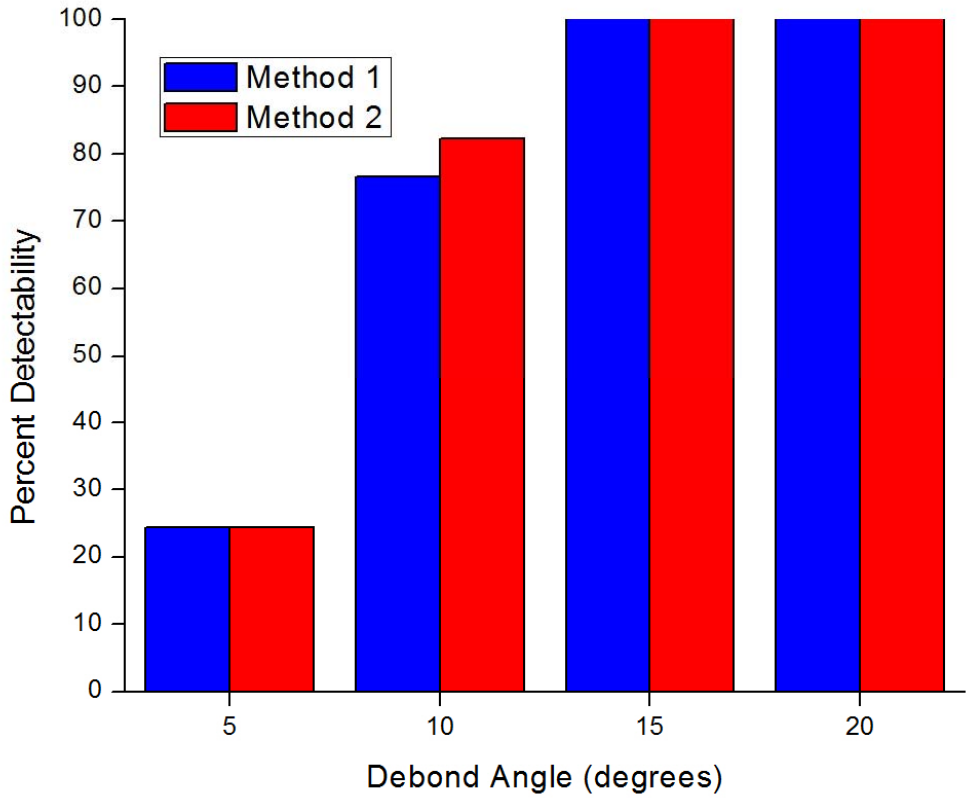
Results and Discussion
Probability of Detection





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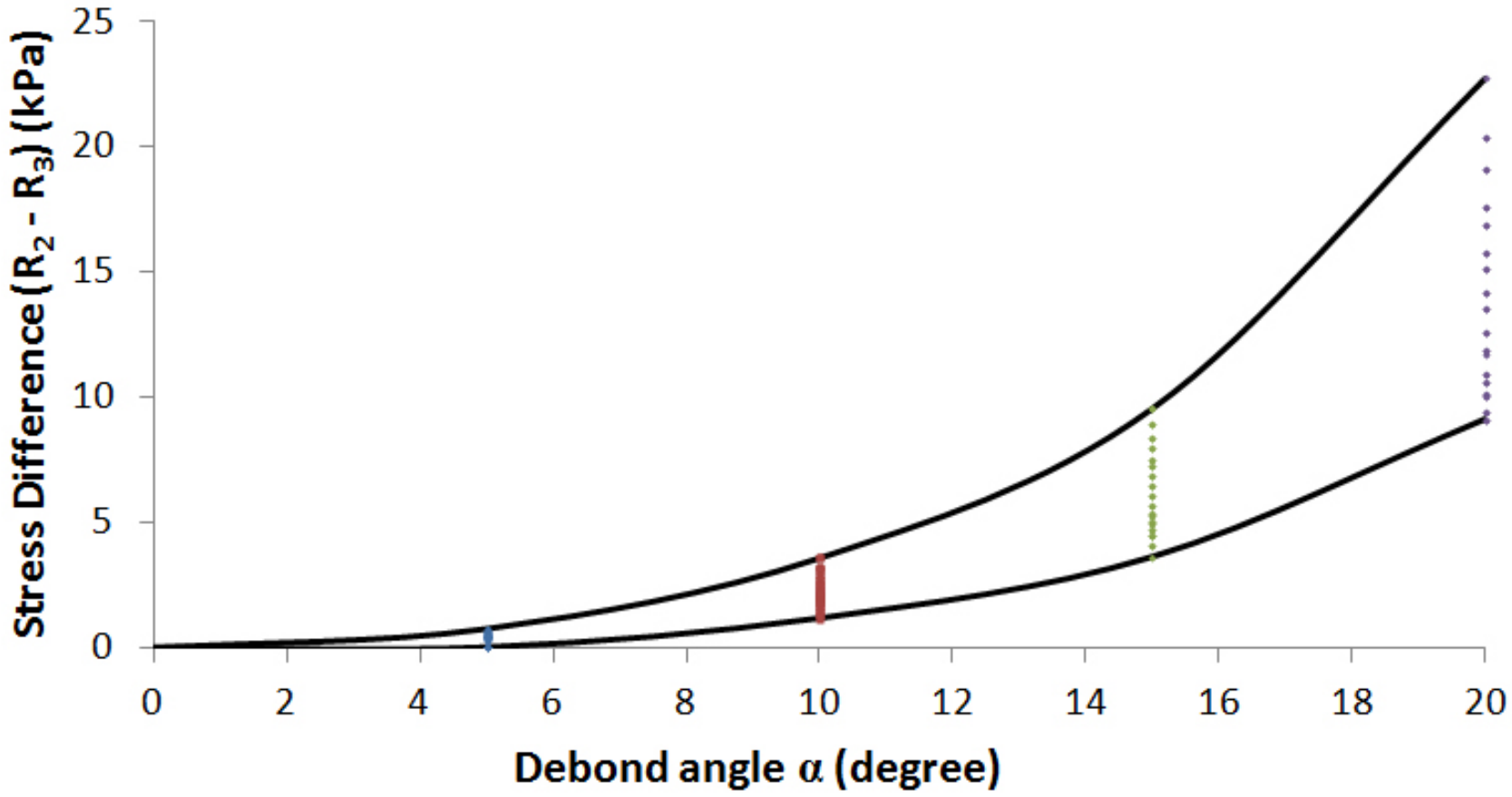
Results and Discussion
Estimation of Total Debond Angle



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Conclusions

- **FEA analysis shows that debonds can be detected with pressure sensors at the case wall. Methodology is described, including:**
  - Differential and baseline methods
  - Effects of test temperature
  - Effects of sensor failure
  - Probability of detection
  - Method to estimate debond size

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